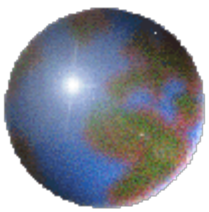
Initial impact of AIRS data on analyses and forecasts at NASA/GSFC

Robert Atlas and Joanna Joiner

Background

- At GSFC we are evaluating the impact of AIRS data in several different forms,
  - NESDIS statistical retrievals
  - AIRS Team physical retrievals
  - 1D VAR interactive retrievals
  - AIRS radiances
- The impact of clear retrievals or radiances vs the addition of partially cloudy data will be evaluated.
- The impact of data over water vs data over both water and land will be evaluated.
- The impact of AIRS will be evaluated using several different DAS: FVSSI, FVDAS, EDAS



Initial impact of AIRS data on analyses and forecasts at NASA/GSFC: Interactive retrievals and radiances

Joanna Joiner, Paul Poli, (Don Frank), Tom King, Genia Brin, Bob Atlas

Outline

- Introduction
- Clear channel identification using a spatial variability approach
  - Simulation results
  - Focus day results (O-B radiances)
  - Comparison with MODIS
- Assimilation results
- Summary

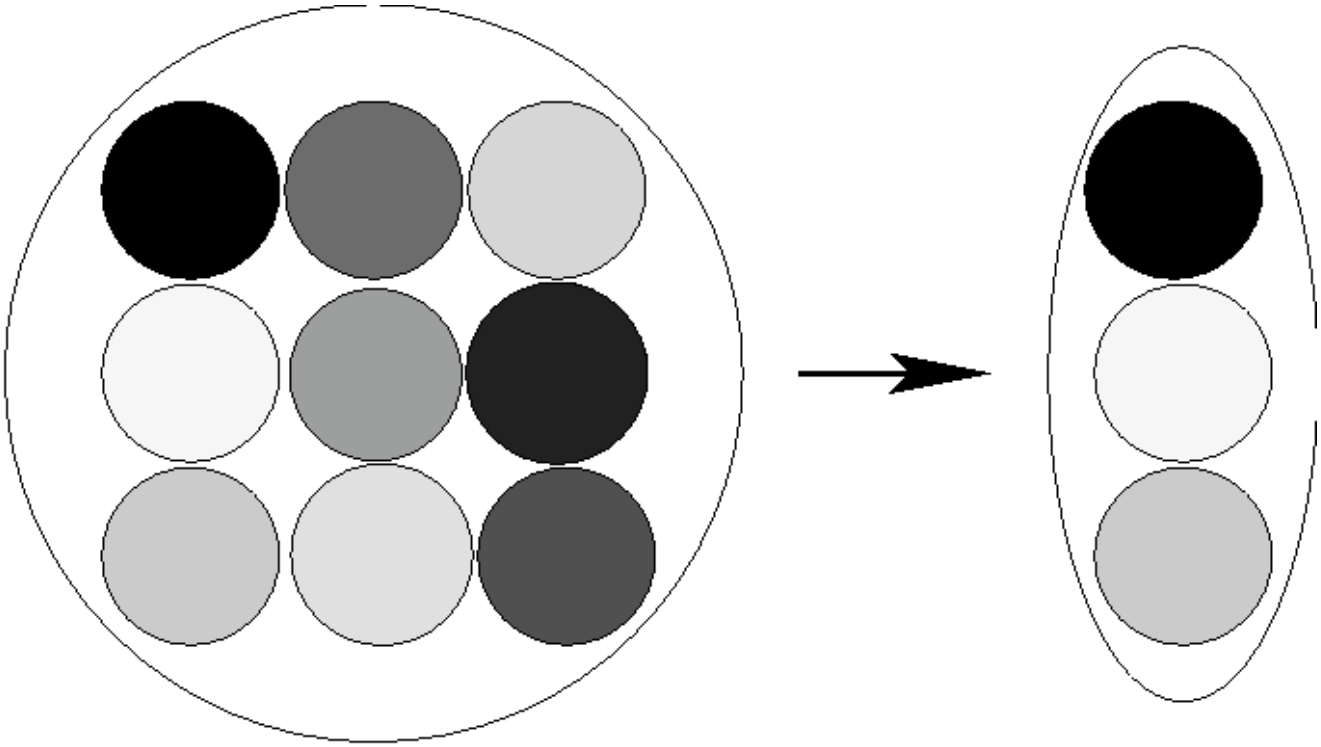
Spatial variability approach

- Assumption: clouds at a given level will have a heterogeneous effect on adjacent-pixel radiances
- Does not rely heavily on information from background (only used when no variability or to define weighting functions)
- Does not assume anything about cloud radiative (spectral) properties or vertical structure
- O-B can be used as independent check
- O-B method could be applied afterwards
- Computationally inexpensive

Spatial approach, cont.

- ~~Maximize radiance contrast within a golfball by partial eigen-decomposition (most of variance captured in first 3 modes)~~
  - Problem: at scan edge – SZA variability maximized
  - Solution: Use single golfball column
- Check if there is significant variability (~50% of golfballs). If not, apply series of clear tests
- Start from ~100 hPa and work downwards, applying test with appropriate channels checking radiance differences in adjacent pixels
  - Mean test: Is mean significantly different from zero? (Improved by taking into account error of mean!)
  - ~~Standard deviation test: Are standard deviations significantly different from those expected?~~

Golfball column reduction



- Use column that has pixel with warmest 11μm brightness temperature

(ensures constant satellite zenith angle)

Monte Carlo Simulations

- Generate true radiances based on model satellite track; 39 latitudes between 18 and 63^{o}N
- For each of the 39 profiles, 100 simulations with 9 FOVs
  - black clouds, two layers, uniformly distributed in pressure and cloud fraction
  - Instrument noise (Gaussian)
  - Background errors (consistent with covariance matrix)

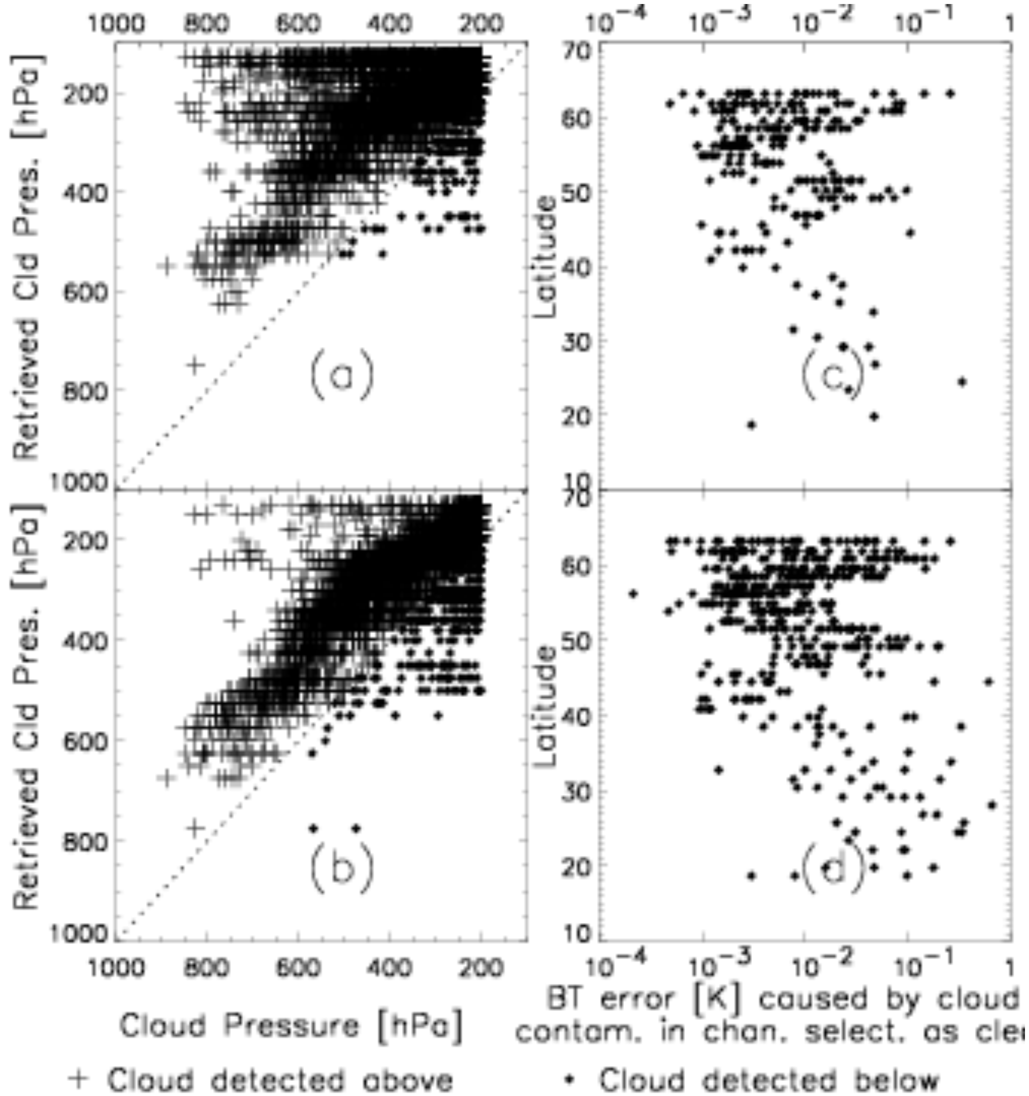
Retrieved vs True (Simulations)

$T_m = 2\sigma$

(more conservative)

$T_m = 3\sigma$

(less conservative)



Estimating radiance errors

- Use clear, adjacent FOVs to estimate detector noise + atmospheric/surface variability
- Detector noise estimates from AIRS science team
- Compute O-B with O=O1 (warmest pixel), O=O3 (average of 3 column pixels) for clear pixels without significant atmospheric/surface variability to get estimates of detector noise (σ_d) and projected forecast error (σ_f)

$$\sigma_f^2 + \sigma_d^2 = \sigma_{(O1-B)}^2$$

$$\sigma_f^2 + \sigma_d^2/3 = \sigma_{(O3-B)}^2$$

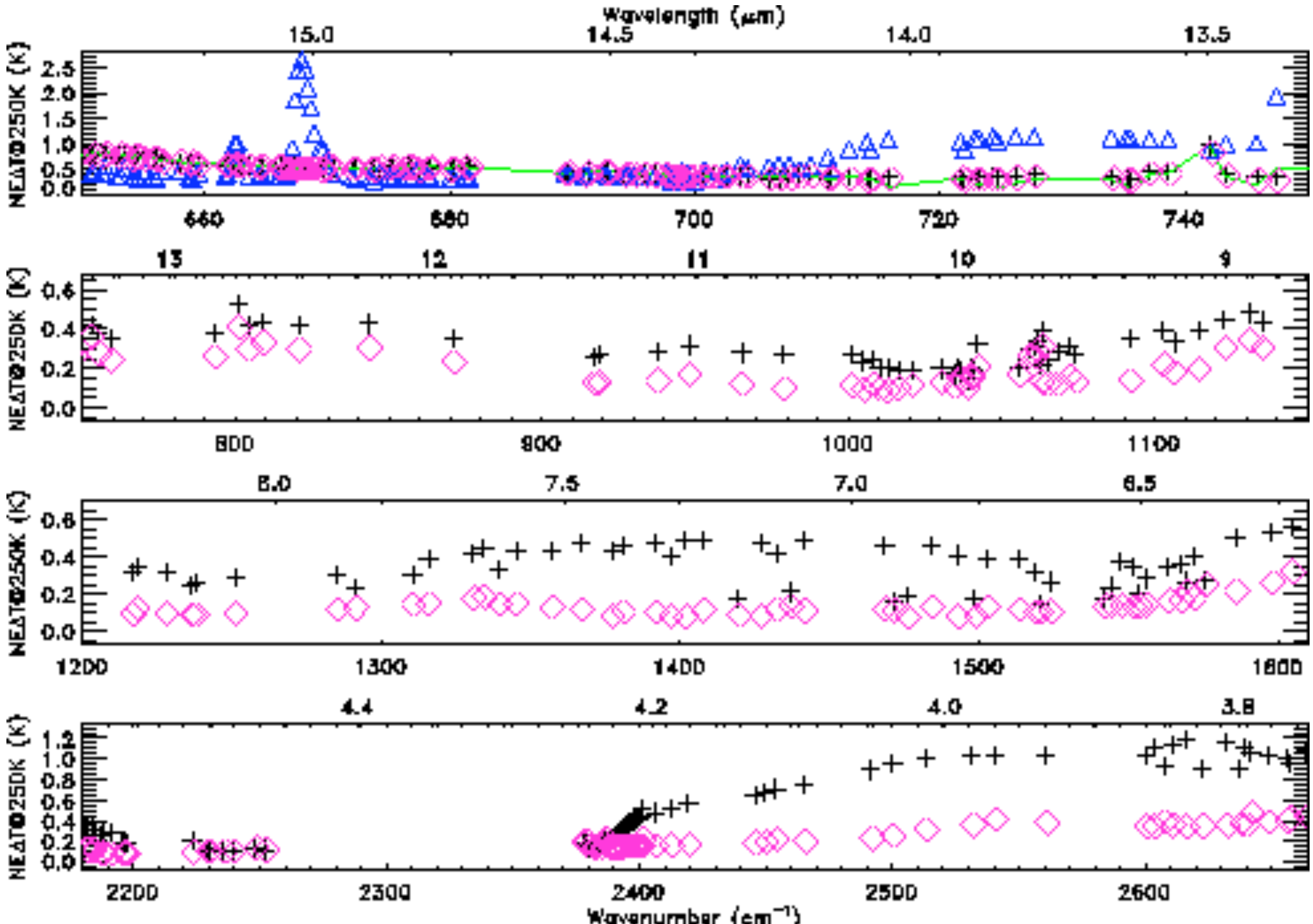
Estimating noise/clear variability

+: Estimated clear variability

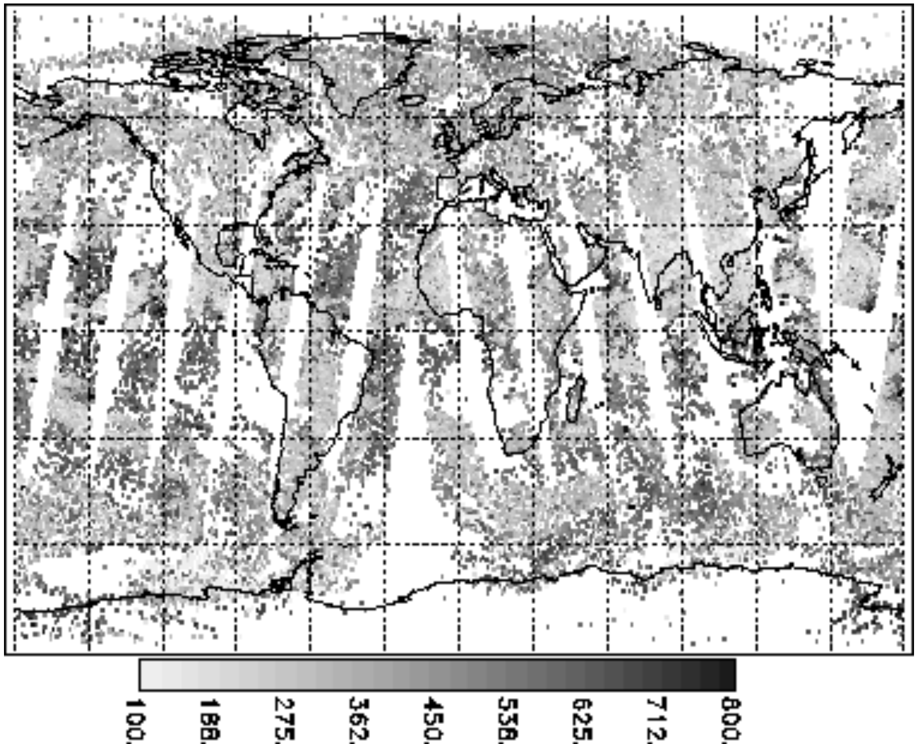
Diamond: AIRS team estimated noise

Triangle: Estimated forecast errors

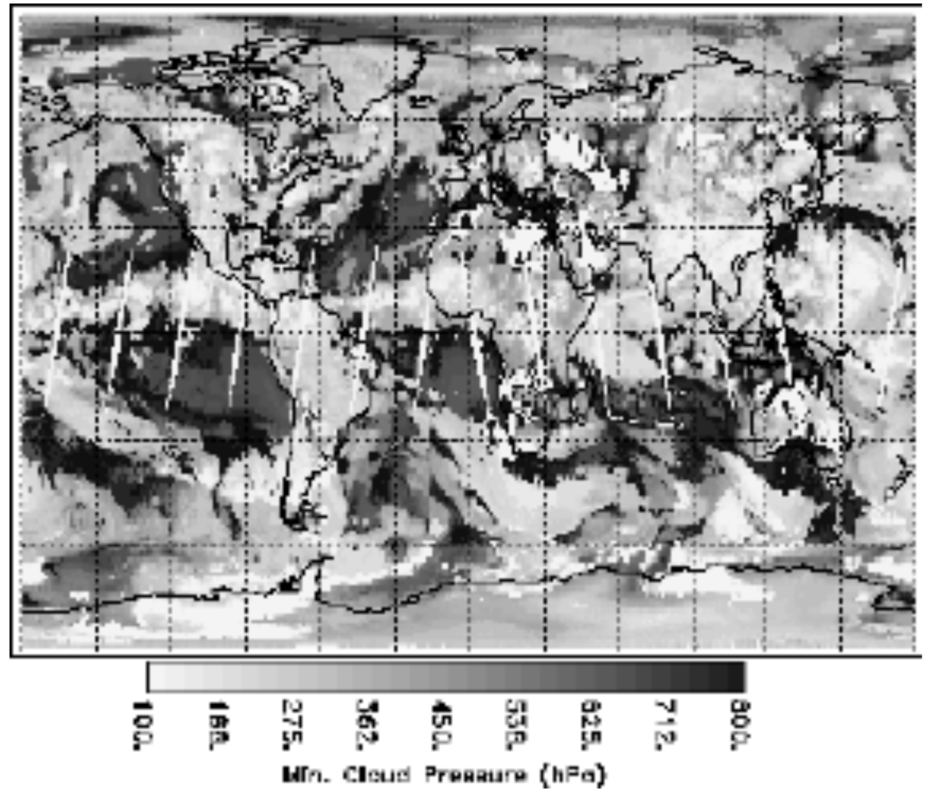
Green: Our noise estimate



Focus day – real AIRS data

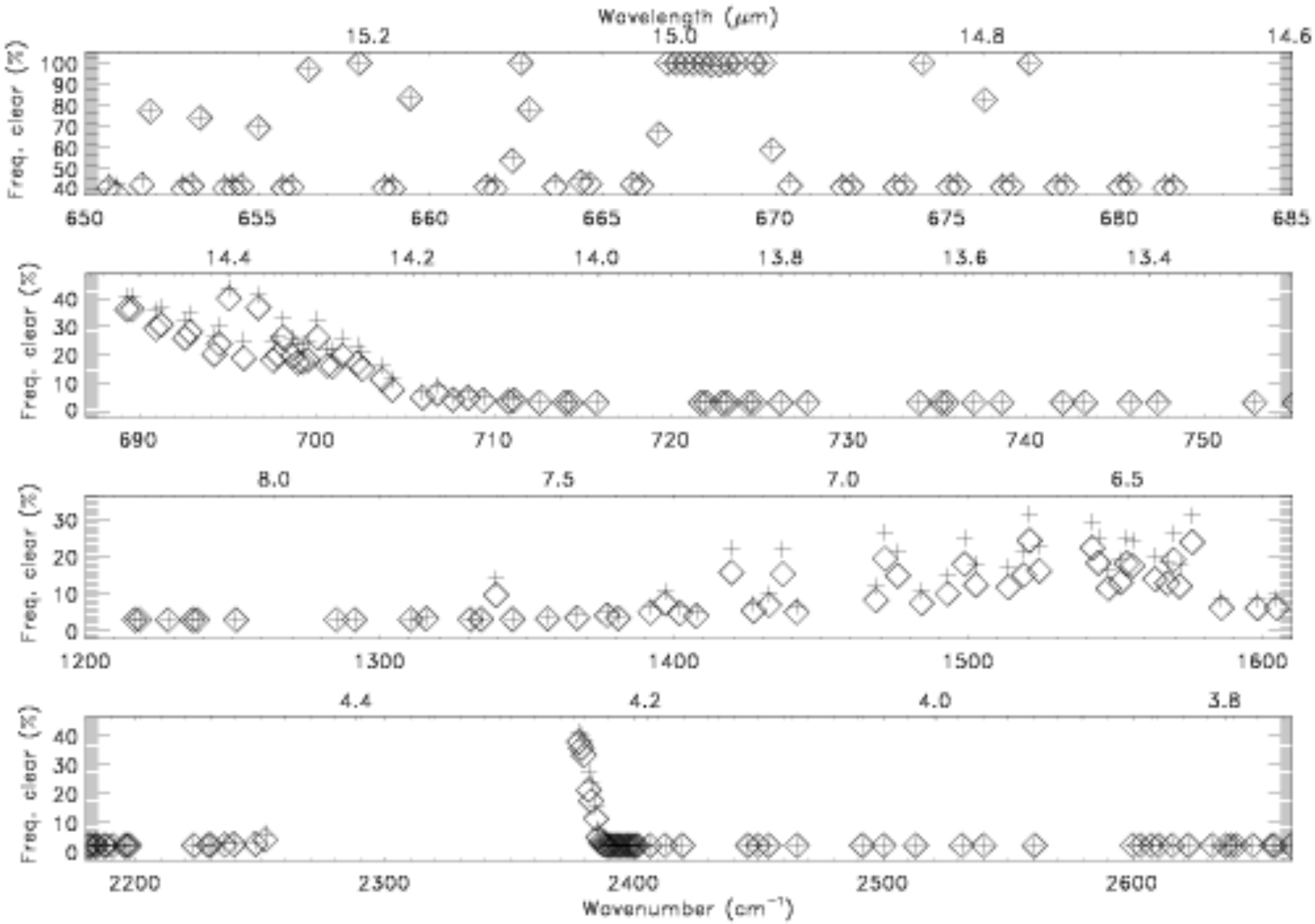


AIRS effective cloud pressure
(More conservative)

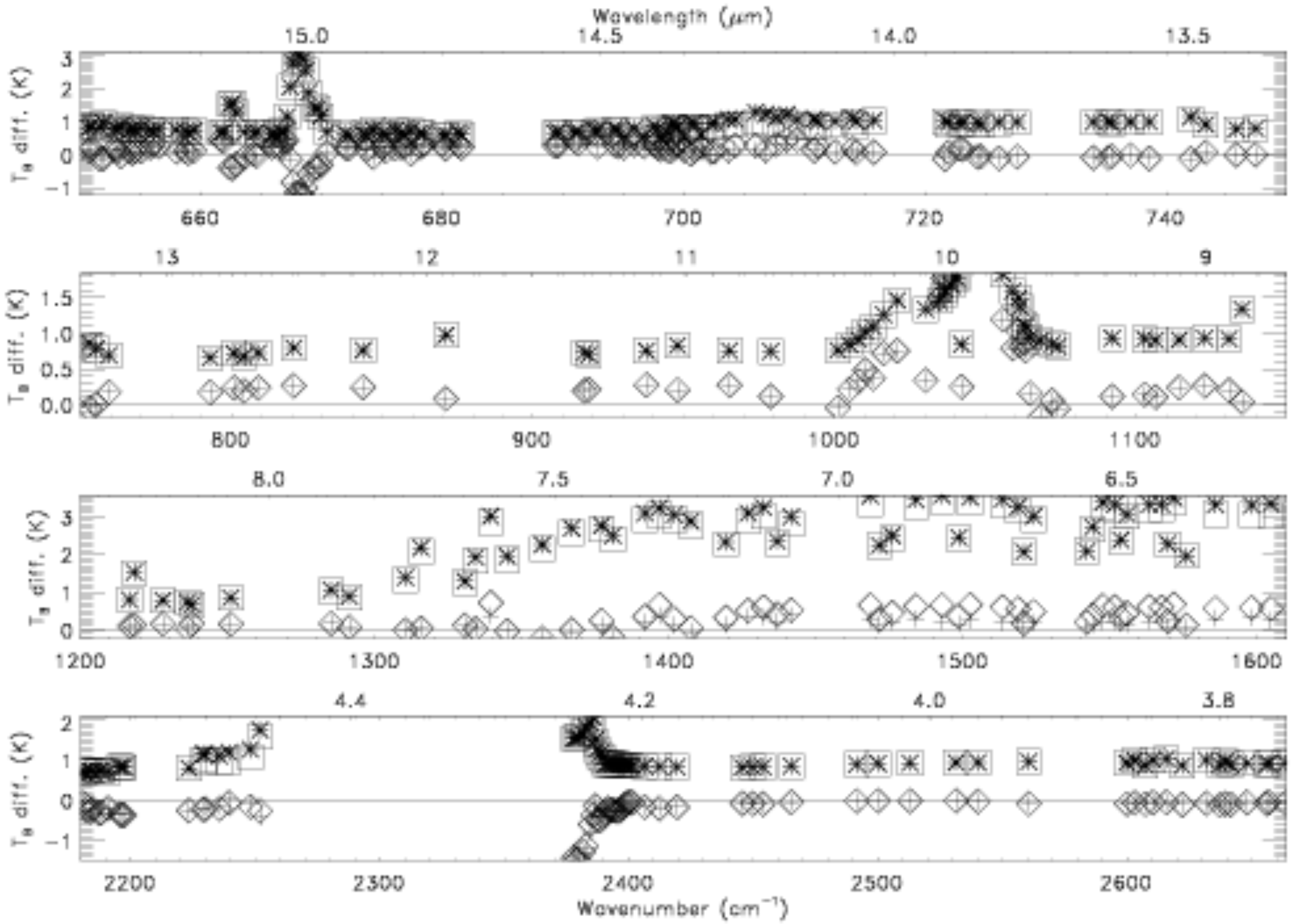


Aqua MODIS L3 minimum
cloud-top pressure

Frequency channels picked



O-B + ◇ :mean, * □ : std. dev.



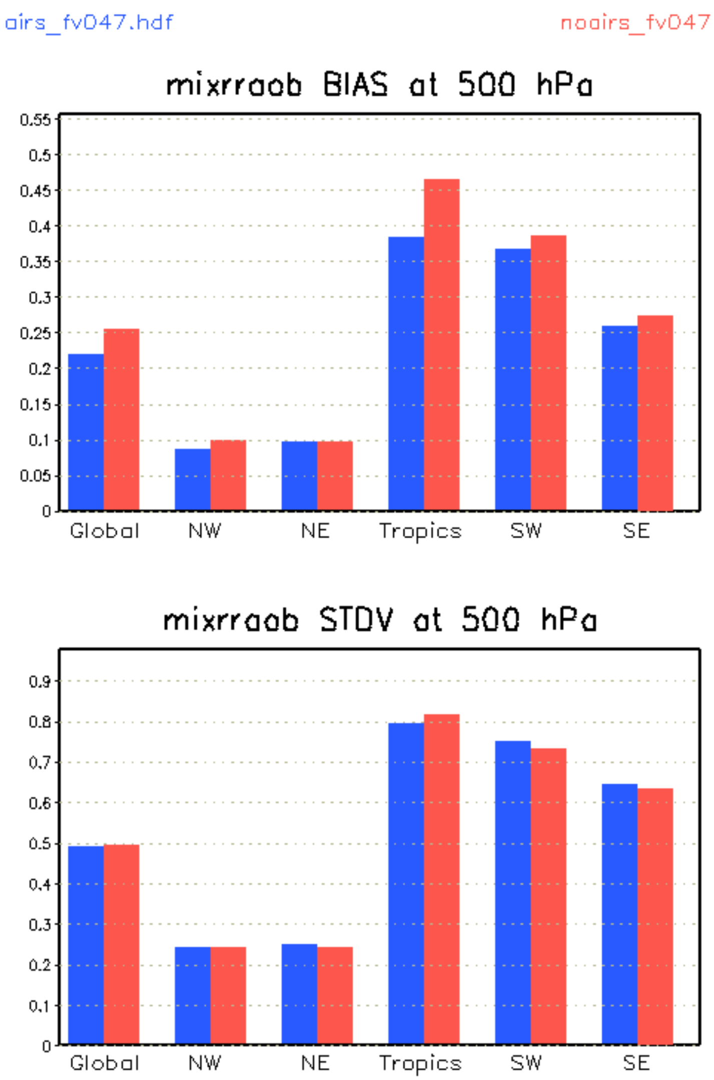
Attributes/problems

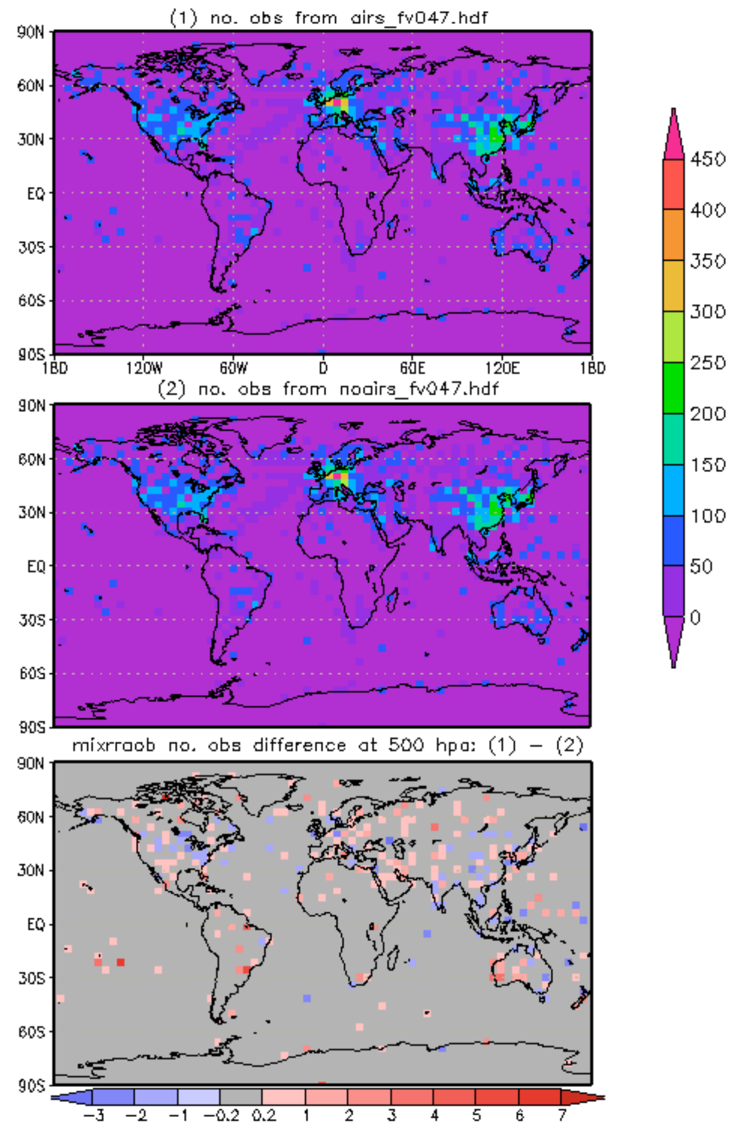
- Preliminary comparison with MODIS, O-B indicates the algorithm appears to be working
- There are very few cases where O-B indicates possible residual cloud contamination
- Correlated radiance errors may cause cloud level to be retrieved too high
- Land-surface variability potentially causes algorithm not to detect clear areas over land
- Mostly, the algorithm errs on the conservative side
- Parameters can be tuned depending on application (can be made more or less conservative)
- Paper on algorithm submitted to QJRMS, under revision

Assimilation Results

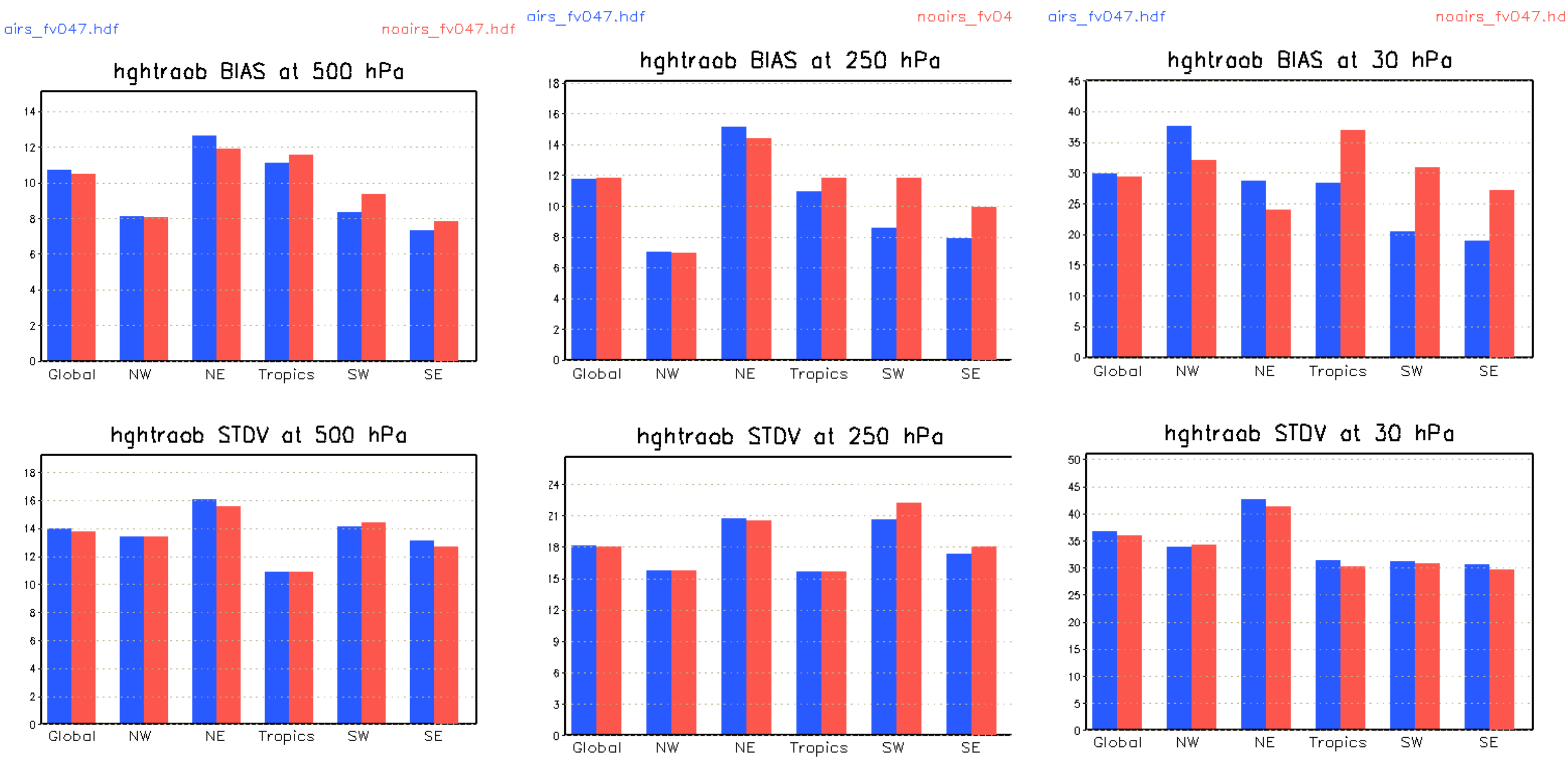
- Finite-volume data assimilation system (fvDAS)
  - 1DVAR with cloud-clearing, assimilate as heights, mixing ratio
  - Thinned to ~ 4 x 5^{o} resolution
  - Model 1 x 1.25^{o} resolution to 0.01 hPa
  - ~180 AIRS channels
- Control: no AIRS (NOAA 15, 16, 17)
- Experiment: where AIRS available, replace NOAA 16 HIRS with AIRS (do not use Aqua AMSU)
  - Focus day (July 20, 2002) shown previously
  - January 2003 (focus on Columbia reentry shown previously) This presentation will focus on monthly statistics.

6 hour humidity forecast vs radiosonde

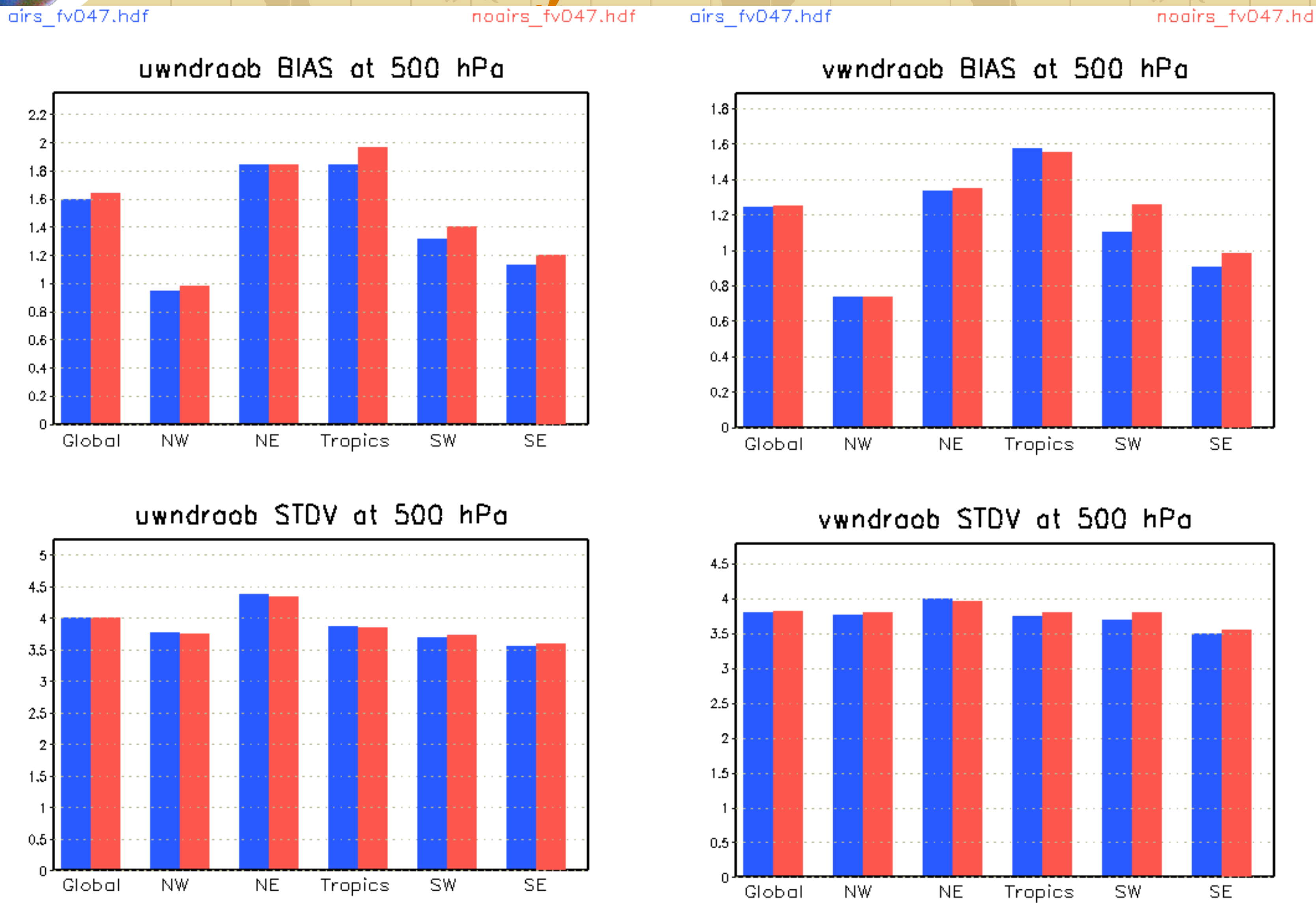




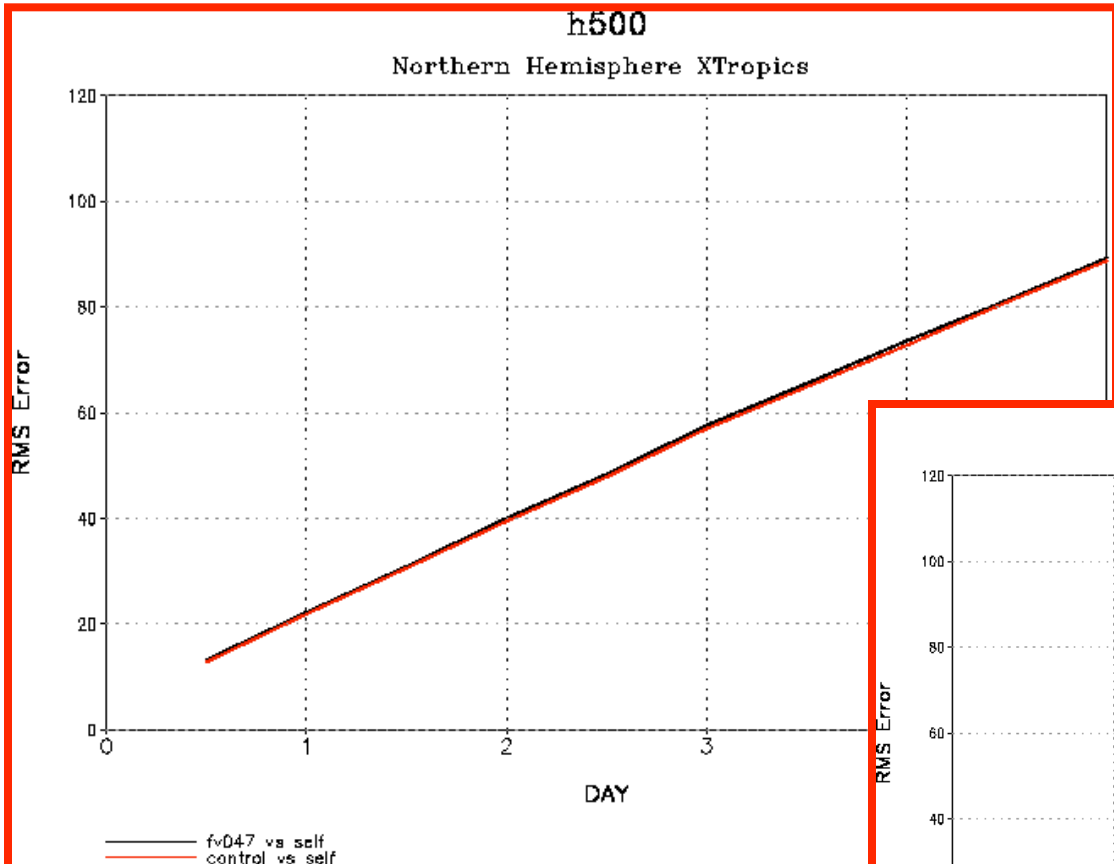
6 hour height forecast vs radiosondes

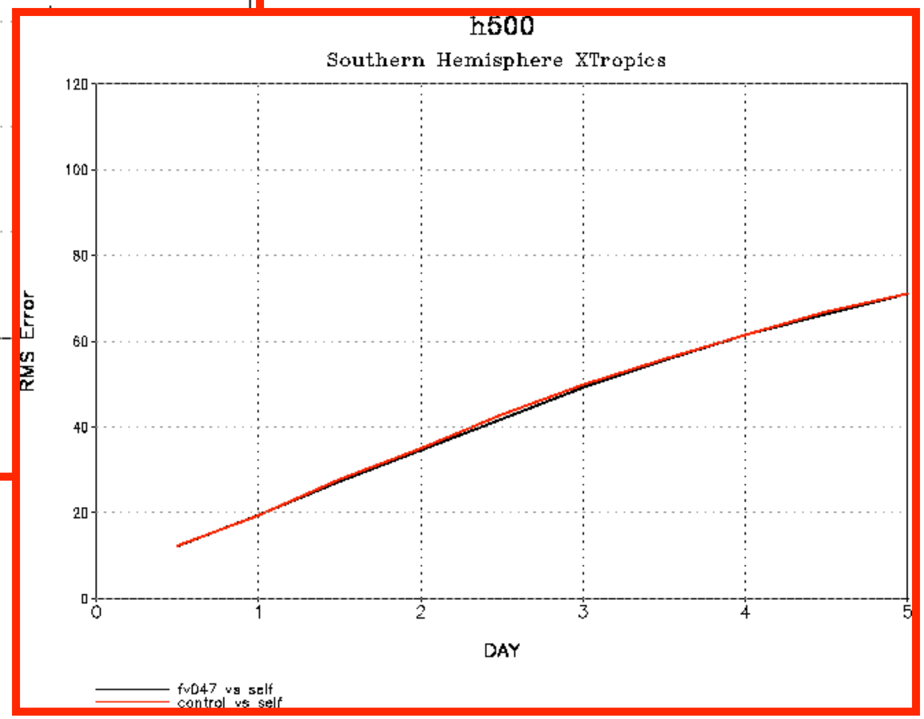


6 hour wind forecast vs radiosondes



5 day 500 hPa height RMS errors





Summary

- Clear channel identification appears to be working; Could be combined with O-B based methods
- Improvement in 6 hours forecast humidity, heights, and winds (reduction of biases as compared with radiosondes) in SH, tropics -> Improved analysis!
- Preliminary AIRS assimilation in fvDAS system shows neutral impact on 500 hPa heights up to 5 days – however, the experiment was not optimal
  - AIRS data thinned to 4 x 5 degree resolution
  - Temperature information assimilated as heights
  - Background and observation errors not optimized

Ongoing Work

- Fine tuning of algorithms ongoing
- Assimilations with hybrid GMAO/NCEP (fvSSI) system ongoing to assimilate different sets of pre-processed radiances
  - Warmest golfball pixel w/NCEP cloud detection
  - " w/GMAO cloud detection
  - Column averaged pixels w/ both cloud detections
  - GMAO Cloud-cleared radiances w,w/o NCEP cloud detection
- Have completed static analyses with GMAO processed radiances
  - Speed of OPTRAN on GMAO computers an issue
  - Have integrated SARTA, MIT RT codes within SSI analysis for increased speed